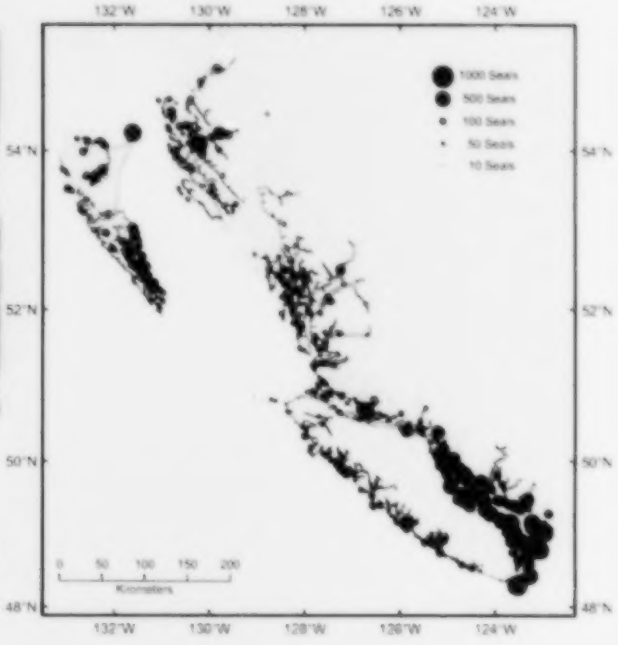
Fisheries and Oceans Canada | Pêches et Océans Canada
Science | Sciences
Pacific Region
Canadian Science Advisory Secretariat
Science Advisory Report 2009/011

POPULATION ASSESSMENT
PACIFIC HARBOUR SEAL (*PHOCA VITULINA RICHARDSI*)

Pacific Harbour Seals (Photo: Peter Olesiuk, Pacific Biological Station, Nanaimo, B.C.)



Map showing distribution and relative size of harbour seal haulout sites in British Columbia. Coastline that has not been surveyed is shown in grey. ➔

Context

The Pacific harbour seal is a medium-sized phocid (true seal) that inhabits coastal waters of the Northeast Pacific Ocean. It ranges along the Pacific Rim from Baja California north to Bristol Bay and west through the Aleutian Islands. It is the only true seal that resides year-round and breeds off the west coast of Canada.

Harbour seals are ubiquitous in coastal waters of British Columbia, and utilize over a thousand haulout sites to rest, moult and give birth. The birth season varies regionally, with most pups being born between mid-May and early-July in northern B.C., and between early-July and late-August in southern B.C.

During 1879-1914 and 1962-1968, harbour seals in B.C. were commercially harvested for pelts, and over-hunting during these two periods depleted populations. Bounty payments offered for predator control during 1914-1964 maintained populations below natural levels.

Aerial surveys indicate that the abundance of harbour seals in B.C. has increased dramatically since the species was protected in 1970. Populations grew exponentially during the 1970s and 1980s, but growth rates began to slow in the 1990s, and the population now appears to have stabilized.

In 2008 it was estimated that about 105,000 harbour seals inhabited coastal waters of B.C., compared with perhaps 10,000 when the first surveys were conducted in the early 1970s. The current population size appears to be similar to pre-exploitation levels that occurred in the 1880s, and recent increases can be attributed to the recovery of populations from over-harvesting.

Canada

SUMMARY

- DFO began conducting aerial surveys in British Columbia in the early 1970s to determine harbour seal abundance and distribution, and monitor population trends. Surveys are flown in small aircraft at low tide toward the end of the pupping season, when maximum numbers of animals are hauled-out and can be counted. Correction factors are applied to account for swimming animals missed during surveys.

- Surveys in the Strait of Georgia and Index Areas in other parts of the province indicate seal populations grew exponentially at a rate of about 11.5% per year during the 1970s and 1980s, which probably represents the biological maximum rate of increase for this species. The rate of increase began to slow in the mid-1990s, and abundance now appears to have stabilized.

- The recent population increases are thought to represent the recovery of population that had been depleted by over-hunting prior to the species being protected in 1970. Approximately half a million harbour seals are estimated to have been killed on the west coast of Canada for pelts or bounty since the late 1870s. Large commercial harvests taken during 1879-1914 and 1962-68 are thought to have depleted populations.

- Seals are widespread and do not congregate to breed, so the entire coastline must be searched to census populations. To date, about 82% of British Columbia's 27,200 kilometer coastline has been surveyed, and nearly 1,400 haulout sites have been identified. The highest densities of harbour seals occur in the protected waters of the Strait of Georgia (13.1 seals per km shoreline), which represents only 11% of the coastline but supports 37% of the seal population. In areas that have been surveyed outside the Strait of Georgia, densities average about 2.6 seals per km of shoreline, and this average has been applied to unsurveyed coastline to estimate total abundance.

- It is estimated that about 105,000 harbour seals currently inhabit coastal waters of British Columbia, compared with a population that had been reduced to perhaps 10,000 when the first surveys were conduced in the early 1970s.

- The B.C. population represents about 29% of the total of 360,000 harbour seals estimated to inhabit the NE Pacific Ocean. Recovery of harbour seal populations has also occurred in California, Oregon, Washington and parts of SE Alaska, renewing concerns over their impact on fishery resources and interest in their role in marine ecosystems.

INTRODUCTION

Species Biology

Harbour seals (*Phoca vitulina*) inhabit temperate and subarctic coastal waters throughout much of the northern hemisphere. Five geographically separated subspecies are recognized. The eastern Pacific subspecies (*P.v. richardsi*) occurs along the Pacific Rim from Baja California northward to Bristol Bay and westward through the Aleutian Islands in Alaska. It is the only true seal (phocid) that resides year-round and breeds on the west coast of Canada.

The Pacific harbour seal is a medium-sized seal with variable pelage ranging in colour from almost white to almost black, but usually mottled with rings, blotches and spots. Pups weigh

about 10 kg at birth, and double their mass during a 3-6 week nursing period. They are precocious and can swim at birth. Females typically grow for 5-7 years and attain a length of 1.4 meters and mass of 65 kg, whereas the slightly larger males continue to grow for 8-10 years and attain a length of 1.5 meters and mass of 85 kg. Maximum longevity is about 29 years for females and 20 years for males, but average life expectancy is 10 years for females and 8 years for males.

Both sexes mature at about 3-5 years of age, and most adult females give birth to a single pup each year. The birth season varies by latitude, with pups born from mid-May to early-July in northern B.C., and from early-July to mid-August in southern B.C. Mating typically occurs about two weeks after pups are weaned. The species is polygamous, with dominance among males established by aquatic displays that include water slapping, bubble blowing, and rolling, as well as agonistic male-male encounters.

Harbour seals are non-migratory and generally occur in coastal waters within 20 km of land, but have occasionally been seen as far as 100 km offshore. They also enter navigable rivers and lakes, and range as far as 250 km up the Skeena River and 500 km up the Fraser River. Harbour seals typically spend a few hours each day hauled out on reefs, sandbars or logbooms, and forage locally within 10-20 km of haulout sites. They are capable of diving to over 500 meters and often forage at night. Telemetry studies indicate a high degree of site fidelity, with the majority of tagged animals remaining at the capture site or neighbouring sites, but seals occasionally make excursions up to several hundred kilometers. Long-term marking studies in Europe indicate females return to natal areas to reproduce.

Harbour seals are opportunistic predators that tend to feed on prey that are locally and seasonally abundant or accessible. Preferred prey appear to be small or medium-sized schooling fishes, which in B.C. include species such as herring, hake, sandlance, salmon, eulachon and sardines. Bottom fish, such as flounder, sole and skate can also be important dietary items, and squid and octopus are sometimes consumed. Daily food requirements of individual animals vary with sex and age, and depend on quality of prey, but average about 1.9 kg per day.

Detailed diet studies in the Strait of Georgia indicated that hake and herring were the two primary prey, which combined accounted for about 75% of the total diet. Herring predominated the diet during winter when migratory herring stocks move inshore in preparation for spawning, and hake predominated the diet during summer after herring moved offshore and hake become more aggregated. Salmon made up only 4% of the overall diet, and were taken mainly in estuaries and rivers when adult salmon were returning to spawn. Although the overall impact on salmon stocks was determined to be quite minor (a few percent of total spawning escapement), seals can have major impacts on some local salmon stocks, especially those that are depleted.

Need for Advice

The harbour seal is one of the most widely distributed and abundant marine mammal on the west coast of Canada. Prior to the early 1970s, populations were not monitored and killing was unregulated, and harbour seal populations were severely depleted by over-hunting. Since being protected in 1970, however, populations have increased dramatically, and appear to have attained peak historic levels. The recovery of populations has renewed concerns over the impact of harbour seals on fishery resources and interest in their role in marine ecosystems.

Harbour seal population assessments are conducted on an ongoing basis to insure

management advice can be provided in a timely manner. Information on seal abundance and distribution is routinely required for responding to issues such as environmental assessments, habitat referrals, siting of finfish and shellfish aquaculture facilities, evaluating impacts on local fishery resources, and assessing effects of predator control kills on local seal populations. Regulations have recently been implemented that allow for culling of nuisance seals that pose a threat to anadromous fish stocks or are inflicting damage to fishing gear or aquaculture operations.

With the implementation of the Oceans Act and shift toward ecosystem-based management, research and management issues have become more diverse. Seal assessments are used in the evaluation of marine protected areas, identifying ecologically and biologically significant areas, identifying ecologically significant species, and in ecosystem modeling and monitoring. Seal assessments are utilized in responding to incidents such as chemical and oils spills, and for impact assessment following such events.

ASSESSMENT

Department of Fisheries and Oceans (DFO) has conducted aerial surveys since the early 1970s to determine the abundance and distribution of harbour seals, and to monitor population trends. Coverage of surveys has been expanded over the years. Baseline surveys have now been conducted in all regions of the province, with 82% of B.C.'s 27,200 kilometers of coastline having been surveyed.

Aerial surveys are conducted during low tides toward the end of the pupping season when peak numbers of animals are hauled out on land. Counts are standardized to account for slight differences in geographic coverage, missed sites, and the timing of surveys. The standardized counts provide a reliable index of relative abundance (Coefficient of Variation=0.064), but underestimate absolute abundance because some animals are in the water and missed during surveys.

Correction factors have been developed to account for animals in the water that are missed during surveys. Miniature electronic recording devices called time-depth recorders (TDRs) were deployed on seals (n=34) in the spring and recovered in late summer. The TDRs provided detailed records of haulout behaviour, and have been used to determine the proportion of animals that would be hauled out under the tidal conditions during which each survey was conducted. It was estimated that on average 62% of animals were hauled out during surveys, resulting in a correction factor of 1.63 (CV=0.042).

In the Strait of Georgia, harbour seal populations increased exponentially at a rate of about 11.5% (95% Confidence Interval 10.9 -12.6%) during the 1970s and 1980s, and then stabilized abruptly in the mid 1990s. Abundance increased about 10-fold from 3,600 (95% *CI* 2,480 to 4,650) in 1973 to 39,000 (95% *CI* 33,200 to 45,000) during 1994-2008. Surveys in Index Areas outside the Strait of Georgia show a similar pattern.

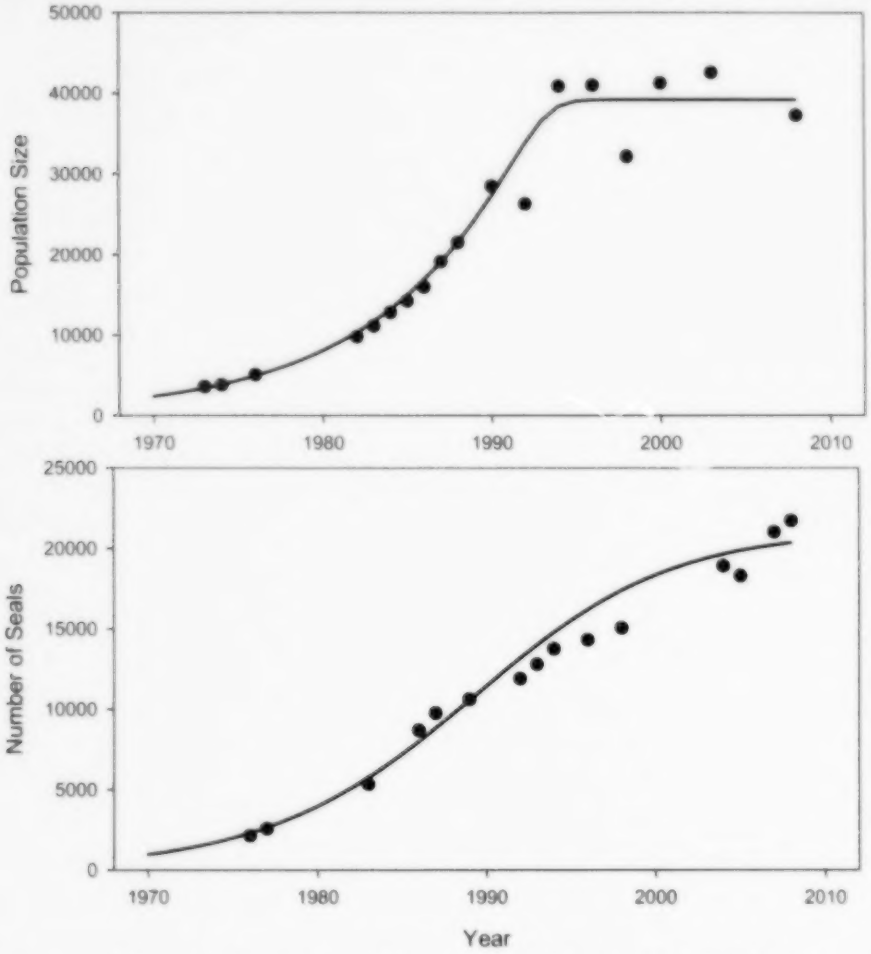


Figure 1. *Recent trends in harbour seal abundance in the Strait of Georgia (top panel) and in Index Areas outside the Strait of Georgia (bottom panel). The Index Areas are widely distributed throughout B.C. and include the lower Skeena River, most of the Queen Charlotte Islands, Queen Charlotte Strait and Broughton Archipelago, and the west coast of Vancouver Island. The trend lines represent generalized logistic curves fitted using maximum likelihood methods.*

Surveys indicate that seals are widely distributed in coastal waters throughout British Columbia, with nearly 1,400 haulout sites having been identified. The importance of haulout sites varies widely, with sites used by anywhere from a few to over a thousand seals. The highest densities of harbour seals occur in the Strait of Georgia, which represents only 11% of the coastline but supports 37% of the seal population. An estimated 39,000 seals (95% *CI* 33,200 to 45,000) inhabit the Strait of Georgia, representing an average density of 13.1 seals per kilometer of shoreline (*CV*=0.24). Outside the Strait of Georgia, densities average about 2.6 seals per km of shoreline (*CV*=0.12), which is significantly lower than in the Strait of Georgia. Applying this density to unsurveyed coastline, its estimated there are about 66,000 seals (95% *CI* 48,100 to 81,900) outside the Strait of Georgia. Total abundance of harbour seals in British Columbia is thus estimated to be on the order of 105,000 (95% *CI* 90,900 to 118,900). Abundance was probably on the order of 10,000 seals when the first surveys were conducted in the early 1970s.

Historic population levels have been back-calculated using a simple model that projected change in population size back through time based on the number of animals harvested for

pelts or killed for predator control, relative to the number of kills that could be sustained by the population. Records of the number of pelts processed and bounties paid were compiled dating back to the first documented commercial kills in 1879. Since some carcasses sink and are lost when shot, the bounty payments and pelt figures probably represent 48-75% of the number of seals actually killed.

During 1879-1968, an estimated 0.5 million seals were killed in British Columbia. The largest kills occurred when seals were commercially harvested for pelts during 1879-1914 and 1962-1968. The projection model indicate the population could not sustain these large kills, and was reduced to low levels by the end of both periods. Between the two periods of commercial harvesting, the government offered bounty payments in most years for seal snouts. The bounty kills did not appear to be large enough to reduce the population, but were sufficient to keep it from recovering. The population increased rapidly after being protected in 1970, and has now attained pre-exploitation levels, indicating it has fully recovered.

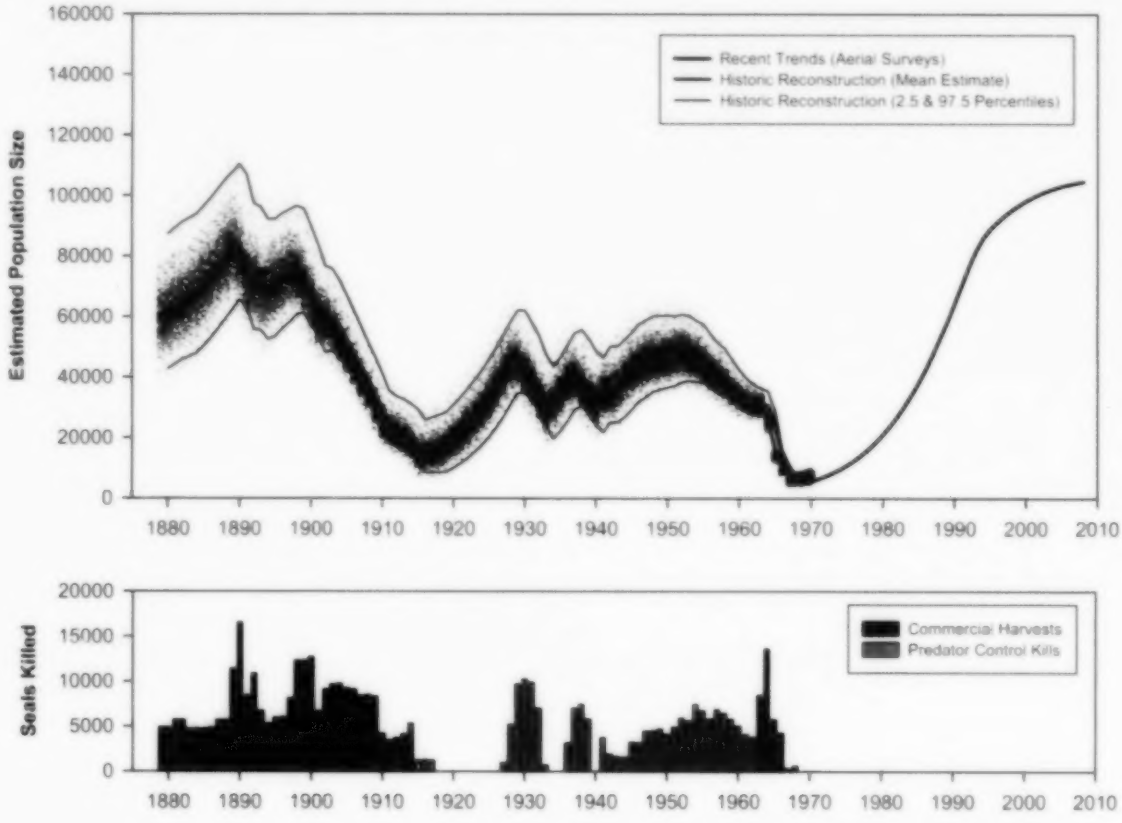


Figure 2. *Harbour seal population trends (top panel) and estimated number of seals killed (bottom panel) in B.C. from 1879 to 2008. The scatter of black dots in the top panel are from simulations and show the plausible range in historic population levels due to uncertainty in the back-calculation model parameters, such as initial population size, population growth rate, and particularly carcass recovery rates. Recent population trends in B.C. were estimated by combining the trends observed in the Strait of Georgia (top panel in Figure 1) and Index Areas outside the Strait of Georgia (bottom panel in Figure 1).*

Sources of Uncertainty

Harbour seals are difficult to census. Animals are widely distributed and spend only a few hours hauled out each day, so small planes are used to maximize coverage during the brief periods seals are on land. Animals are cryptic and widely distributed in small groups, and hard to detect, which can result in abundance being underestimated if animals are overlooked during surveys. This bias is minimized by using experienced observers, conducting detailed searches of the entire shoreline within the survey area, and making counts from photographs.

Abundance is estimated when the population is at its seasonal peak at the end of the pupping season. Surveys are generally conducted after most pups have been born, and corrections are applied to account for any pups born after the survey. Life tables constructed from specimens collected in the 1970s indicated that pups comprised 20% of the population at the end of the pupping season. Correction factors to account for unborn pups thus range from 1.25 for surveys conducted before any pups have been born to 1.00 for surveys conducted after all pups have been born. However, the magnitude of this correction may have changed in recent years as a result of demographic changes in the population as growth rates slowed and abundance stabilized. It is also possible that the birth season may have changed over time, and there some uncertainty regarding the geographic variability in the birth season between northern and southern B.C. Recent surveys have been conducted toward the end of the pupping season, so these biases are probably small but warrant further investigation.

All animals are never hauled out simultaneously, and its impractical to census seals when they are dispersed at sea. In contrast to some other pinnipeds, harbour seals do not congregate on rookeries to breed, and harbour seal pups enter the water within a few hours of birth, making it difficult to monitor pup production. Population trends are based on counts of animals of both sexes and all ages at haulout sites. Numbers of seals on land can fluctuate dramatically over the course of a few hours, and some haulout sites are only exposed at low tide. Surveys are timed to coincide with low tide when peak numbers of animals are ashore, and corrections are applied to adjust for the proportion of animals at sea and missed during surveys. These correction factors are based on detailed analyses of data from time-depth recorders, which indicate that haulout patterns are dictated primarily by tide and time-of-day, but can also be influenced by substrate type, season, sex and age. There is some evidence pups may spend more time in the water after being weaned, but time-depth recorders have not been deployed on these young animals. The correction factors were based on instruments deployed in the early 1990s when populations were still increasing, and its possible that activity budgets and proportion of time hauled out, and hence the correction factors, have changed in recent years as abundance stabilized.

Some sites were likely missed during the first surveys in the early 1970s, resulting in the population growth rates having been overestimated. The flight paths of the early surveys in the Strait of Georgia were re-examined in relation to distribution of haulout sites, and a subjective adjustment applied to account for this bias. As a result, the estimated rate of increase in the Strait of Georgia was adjusted from 13.0% to 11.5%. This bias probably also applies to early surveys conducted in other regions, but there is insufficient information on flight paths to adjust for it.

About 18% of the BC coastline has never been surveyed. Abundance of seals in unsurveyed areas has been extrapolated based on average densities observed in areas that have been surveyed outside the Strait of Georgia. This assumes that the surveyed coastline is representative of unsurveyed coastline. In reality, seal densities can vary according by habitat type, and the long narrow fjords, where the lack of haulout sites makes it difficult to accurately

census seals, are under-represented. However, the overall bias is probably relatively small as its estimated that only 14% of total B.C. population occurs in unsurveyed areas.

Historic population levels have been reconstructed using models that require a number of assumptions about population productivity levels, carcass recovery rates, and initial population size. Simulations using a realistic range of parameter values were conducted to assess the effect of these uncertainties. As a result, the reconstructions cannot be expected to yield precise estimates of population size, but probably reflect general trends. It seems clear that the low population levels observed when surveys were initiated in the early 1970s were far too low to have supported the large commercial harvests taken during 1879-1914 and 1962-1968, so historic population levels must have been much higher. The back-calculation model does not account for density dependence, which would reduce sustainable kill levels for populations near carrying capacity. Forward-projecting models that allow for density dependent indicate that peak population levels in the late 1800s may have been somewhat higher than estimated.

Stock structure of this population is unknown, but there are regional differences in the timing of pupping. Telemetry studies have shown that harbour seals tend to exhibit a high degree of site fidelity, and translocated animals usually return to where they were captured. Genetic studies of harbour seals in Alaska found significant differences in DNA, indicating a lack of mixing, over distances of a few hundred kilometers. Its unlikely that harbour seals in B.C. constitute a single panmictic population, but subpopulations have not been identified.

Outlook

Abundance of harbour seals in British Columbia has increased ten-fold since the species was protected in 1970. Populations have also increased off California, Oregon, Washington, and parts of SE Alaska. However, growth has slowed or stabilized in each region, suggesting that populations are approaching or have attained carrying capacity. Indeed, historic reconstructions indicate current population levels in B.C. may be similar to peak historic levels that occurred in the 1880s before any large-scale commercial kills.

Given the recovery of harbour seal populations, it can be anticipated that natural regulatory mechanisms will begin to play a greater role in local waters. Populations in local waters have been maintained below natural levels during the last century, so little is known about how populations are regulated. In Europe, where harbour seal populations have also recovered from over-hunting, a disease outbreak subsequently reduced seal numbers by up to half, but populations have since recovered and experienced a second outbreak.

OTHER CONSIDERATIONS

The recovery of harbour seal populations has renewed concerns over conflicts with fisheries and the impact of seals on fish stocks. Our understanding of the feeding habits of harbour seals and their role in the ecosystem are still poorly known. Additional research will be required on the diet, foraging patterns, and energy requirements to assess seal – fishery interactions.

Harbour seals have been recognized as being an ecologically significant species in B.C., both as a high-level predator and an important prey species for transient killer whales, their main predator. Indeed, numbers of transient killer whales foraging in local waters may be correlated with the abundance of harbour seals. With the recent shift toward ecosystem-based management, there may be potential for using species like the harbour seals as a general

indicator of the status of food webs in the North Pacific. The species has also been used as a sentinel for chemical contaminants in high-level predators in marine food webs.

CONCLUSIONS AND ADVICE

Harbour seal populations were severely depleted by over-hunting during commercial harvests in 1879-1914 and 1962-1968, but have made a dramatic recovery since being protected in 1970. There are currently about 105,000 harbour seals on the British Columbia coast, which is likely similar to pre-exploitation levels that occurred in the 1880s.

Baseline surveys need to be completed to remove uncertainties about seal densities and distribution in unsurveyed areas, and trend surveys in Index Areas need to be continued to monitor and update population status. The correction factors used to adjust for pups born after surveys, and animals missed because they were at sea during surveys, need to be re-examined to determine if they have changed with population status.

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